

THE DARK SECTOR

Gravitational-State and Epistemic-Field Hypotheses

A four-dimensional research extension of “All Is Epistemic”

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AO IS THE PREMISE. THE MODEL IS THE TEST. REALITY HAS VETO POWER.

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Research status and scope

This manuscript is a conditional research extension of Theory of Everything — All Is Epistemic. It asks whether a gravitational/computational state sector and a candidate epistemic scalar field can jointly account for some phenomena currently attributed to dark matter and dark energy. The manuscript is formulated on the observed 3+1-dimensional spacetime arena.

The starting instruction is deliberately demanding: ask the model to produce a dark-sector explanation, then test the answer against conservation, stability, cosmological evolution, structure growth, lensing, and gravitational-wave observations. A verbal resemblance to the observed universe is not a derivation. A finite equation is not automatically a physical mechanism.

Three evidence labels are used throughout:

Label	Meaning
ESTABLISHED PHYSICS	A standard result within its stated theory and assumptions, or a result supported by observations.
MODEL CONSEQUENCE	A mathematical consequence of the explicitly stated 4D action or equations.
TOE CONJECTURE	A proposed physical identification or mechanism not yet derived from A0 or confirmed experimentally.

Executive result

The most economical research direction is a two-sector hypothesis that does not introduce dark-sector properties by naming them. It asks whether (i) a stable, nonrelativistic population of massive gravitational states can supply a dark-matter-like stress-energy component and (ii) the candidate I field can supply a slowly varying, dark-energy-like component. A common microscopic origin is a possible unification, not an established conclusion.

The revised formulation places both candidate mechanisms directly in the observed 3+1-dimensional spacetime. The dark-matter hypothesis must specify a consistent 4D massive spin-2 or other gravitational-state theory, while the I-field hypothesis must stand on its own 4D action, normalization, renormalization prescription, and coupling to quantum correlations.

The central result at this stage is therefore a constrained research program—not a solution to the dark-sector problem. The field dimensions can be made internally consistent. The microscopic source, production history, lifetime, potential, and observable signatures remain to be derived.

1. The problem to be solved

In the standard cosmological model, observations require a dominant nonbaryonic matter component to explain gravitational clustering and a late-time component with sufficiently negative effective pressure to account for accelerated expansion. The labels “dark matter” and “dark energy” summarize distinct phenomenological roles; they do not prove those roles arise from one substance.

A useful extension must explain more than the background expansion. It must reproduce the measured expansion history, the growth of density perturbations, gravitational lensing, cosmic microwave background constraints, and the distribution of matter across scales. It must also avoid unstable fields, negative-norm excitations, unacceptable fifth forces, and uncontrolled energy exchange.

The parent TOE contributes A0 — ALL IS EPISTEMIC — and proposes that physical differentiation, relation, measurement, and information are aspects of one reality. A0 does not uniquely select an action, particle content, coupling, potential, or cosmological history. Those are additional model choices and must be assessed independently.

2. Four-dimensional dynamical framework

Use metric signature $(-,+,+,+)$ and natural units $\hbar = c = 1$ for field-theory dimensional analysis. The reduced Planck mass is $M_p = (8\pi G)^{-1/2}$. All dynamical fields and sources in this manuscript are defined on ordinary four-dimensional spacetime.

$$S = \int d^4x \sqrt{(-g)} \left[(M_p^2/2)(R - 2\Lambda) + \mathcal{L}_{SM} + \mathcal{L}_X + \mathcal{L}_I + \mathcal{L}_{int} \right] \quad [2.1]$$

Here $\mathcal{L}_{SM}$ denotes the Standard Model sector, $\mathcal{L}_X$ a proposed gravitational-state sector, $\mathcal{L}_I$ the candidate epistemic field, and $\mathcal{L}_{int}$ any explicitly specified interactions. Splitting the action this way is bookkeeping; it is not evidence that these sectors are independent or that the proposed terms occur in nature.

Metric variation yields the usual Einstein equation with the total stress-energy tensor. The contracted Bianchi identity requires covariant conservation of the total source. If the sectors exchange energy, their separate continuity equations may have source terms, but the sum must remain conserved.

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = M_p^{-2} T_{\mu\nu}(\text{total}), \quad \nabla^\mu T_{\mu\nu}(\text{total}) = 0 \quad [2.2]$$

Any proposed dark-sector interaction must respect diffeomorphism invariance or state precisely how the symmetry is modified. A phenomenological term cannot be used to evade conservation by silently treating the geometry as an unlimited energy reservoir.

3. The graviton qdit: hypothesis and mathematical boundary

3.1 What established spin-2 theory says

A massless spin-2 field in four-dimensional Lorentz-invariant gravity has two radiative helicities, +2 and -2. A conventional massive spin-2 representation has five physical polarizations, with helicities -2, -1, 0, +1, and +2, provided its field equations and constraints are consistent. This polarization count is not evidence that a graviton is fundamentally a five-level quantum-information register.

The TOE hypothesis is stronger: a gravitational degree of freedom may carry a five-state computational register, written abstractly as $\mathcal{H}_q \cong \mathbb{C}^5$. The relation between that register and the five polarizations of a massive spin-2 field is not assumed to be an identity. The microscopic state space, Hamiltonian, Lorentz transformation properties, gauge constraints, and measurement map must be specified.

3.2 The 24-generator algebra

$$\text{End}(\mathbb{C}^5) = \text{span}_{\mathbb{C}}\{1\} \oplus \text{span}_{\mathbb{C}}\{T_A : A = 1, \dots, 24\} \quad [3.1]$$

The decomposition states that a 5×5 complex operator space contains an identity component and 24 linearly independent traceless generators; under conjugation by $SU(5)$, the traceless part transforms as the adjoint representation. This is a mathematical property of the five-level operator algebra. It does not imply 24 additional fields, 24 new particles, a physical $SU(5)$ gauge symmetry, or additional directions in spacetime.

A formal interaction such as $H_{int} = \Sigma_A g_A T_A \Phi_A(x)$ is not yet a physical model. It becomes one only when the fields Φ_A , Lorentz character, mass dimensions, dynamics, allowed symmetries, coupling values, and measurable consequences are defined. The dark-sector manuscript does not promote that formal expression to an established interaction.

3.3 Conditions for a viable massive gravitational state

If the dark-matter candidate is a massive spin-2 excitation, the theory must define its mass and nonlinear completion or its effective-field-theory cutoff. It must show that constraints remove unphysical degrees of freedom, avoid a negative-norm ghost within the domain of validity, remain perturbatively controlled, and approach General Relativity where observations require it. The five-state qdit interpretation adds a separate burden: it must define a computational observable beyond the conventional polarization count.

A stable, nonrelativistic massive state can behave approximately as pressureless matter at the background level. That statement is conditional on its equation of state, production history, interactions, and lifetime; none follows from the number five alone.

4. A 4D gravitational-state candidate for dark matter

Define X as a candidate population of massive gravitational states with mass m_X . This is a phenomenological placeholder pending a complete microscopic action, not a claim that standard massless gravitons form dark matter. The background component behaves as cold matter only in the regime where the typical particle speed is nonrelativistic and pressure and anisotropic stress are sufficiently small.

$$\dot{\rho}_X + 3H(\rho_X + p_X) = -Q_X \quad [4.1]$$

The source Q_X represents energy transferred out of the X component under the sign convention shown. The other sectors must contain compensating terms so that the total stress-energy remains conserved. In the stable, uncoupled, nonrelativistic limit, $Q_X = 0$ and $p_X \approx 0$:

$$\rho_X(a) \approx \rho_{X,0} a^{-3} \quad [4.2]$$

The a^{-3} dilution is the standard continuity-equation result for pressureless matter in an expanding homogeneous universe. It is not a distinctive prediction of the TOE; the distinctive prediction would have to concern why the X states exist, their mass, their abundance, their interactions, or their perturbation behavior.

4.1 Relic abundance and stability

A viable candidate must produce the observed cosmological dark-matter abundance without an arbitrary post hoc normalization. Its production mechanism might involve a specified early-universe process or a calculable nonthermal population, but the relevant matrix elements, initial conditions, and reheating history must be supplied before the relic density can be computed.

$$\Omega_X h^2 = (m_X n_{X,0})/(\rho_{\text{crit},0}/h^2) \quad [4.3]$$

The target value is to be fitted to current cosmological data with the same parameter set used elsewhere in the model. No numerical prediction for $\Omega_X h^2$ is claimed here because m_X , the production rate, and the initial state have not yet been derived.

The lifetime must be much longer than the age of the universe unless the model derives a permitted decay history and its observable products. For a dominant present-day component, a short lifetime would invalidate the simplest stable relic branch.

4.2 Production channels to calculate—not assume

- Primordial production: solve the mode equations in a specified expanding background and compute the final occupation number from defined initial conditions.
- Gravitational freeze-in: calculate the production rate from the explicit 4D interaction vertices and integrate the Boltzmann equation through the thermal history.
- Coherent production: identify the field variable whose homogeneous oscillations represent X quanta, show when oscillations begin, and compute the energy fraction after accounting for expansion and backreaction.

- Decays or conversions: compute branching fractions and rates from the action and compare the resulting abundance and radiation injection with cosmological bounds.

These channels are alternatives until one is derived and selected. They must not be added together to raise the abundance without a consistent calculation that avoids double-counting.

5. Structure formation, lensing, and strong constraints

The dark-matter test is not merely whether ρ_X scales like a^{-3} . A viable component must cluster with the observed timing and scale dependence while remaining consistent with the cosmic microwave background and gravitational-lensing maps. A massive spin-2 population may carry anisotropic stress or additional perturbation modes; those effects must be derived rather than set to zero for convenience.

5.1 Linear perturbations

The model must calculate the transfer function $T_X(k)$, the growth rate, and the metric potentials for scalar perturbations. In a conventional notation with Newtonian-gauge potentials Φ and Ψ , gravitational lensing responds to their sum while nonrelativistic motion is principally sensitive to Ψ . A predicted slip $\Phi - \Psi$, scale-dependent growth, or oscillatory feature can be useful only if its magnitude is computed and compared with data.

$$k^2(\Phi + \Psi) = -8\pi G a^2 \Sigma_{\text{lens}}(k,a) \rho_m \delta_m \quad [5.1]$$

Equation 5.1 is schematic: Σ_{lens} denotes a possible model-dependent modification of the lensing relation, and the exact normalization and sign depend on metric and Fourier conventions. In the General Relativity limit, the appropriate standard Poisson and lensing relations must be recovered.

5.2 Gravitational-wave consistency

The gravitational sector must recover the observed low-energy gravitational-wave speed and the measured tensor waveform behavior. Additional polarizations, dispersion, damping, mode conversion, or a state-dependent phase shift are candidate tests only if the theory predicts them quantitatively. The current manuscript does not claim an observed qdit signature or a direct detection of an individual graviton.

6. The epistemic field in 4D

6.1 Canonical action and mass dimensions

Let $I(x)$ be a real, canonically normalized scalar candidate. In four-dimensional natural units, the action is dimensionless, d^4x has mass dimension -4 , and the Lagrangian density has mass dimension $+4$. The canonical kinetic term therefore fixes the field dimension:

$$\mathcal{L}_I = -\frac{1}{2} \partial_\mu I \partial^\mu I - V(I), \quad [I] = 1 \quad [6.1]$$

The bracket $[\cdot]$ denotes mass dimension, not a quantum expectation value. A canonical scalar field in four spacetime dimensions has mass dimension one.

If the potential contains a quadratic mass term, $V(I)$ contains $\frac{1}{2} \mu_I^2 I^2$, then $[\mu_I] = 1$ and $[\mu_I^2] = 2$. The potential density must have mass dimension four term by term. Any proposed noncanonical kinetic function or composite definition of I would require a new dimensional audit and a stated normalization convention.

6.2 Correlation-sensitive coupling as a model ansatz

As a minimal toy model, introduce a canonically normalized scalar χ and a cubic interaction $-g I \chi^2$ in the Lagrangian. The coefficient g then has mass dimension one. This interaction is permitted by elementary dimensional analysis; that does not establish that it occurs in nature, that χ represents a known sector, or that the interaction is generated by A_0 .

$$\mathcal{L}_{\text{int}} = -g I \chi^2, \quad [\chi] = 1, \quad [g] = 1 \quad [6.2]$$

Define $G_{\text{ren}}(x)$ as a specified renormalized coincident two-point function, schematically $G_{\text{ren}}(x) = \langle \chi^2(x) \rangle_{\text{ren}}$. A change between two physical states on the same background can be denoted $\Delta G = G_{\text{ren}, \text{state 2}} - G_{\text{ren}, \text{state 1}}$. In a homogeneous static mean-field approximation, a quadratic potential and the stated interaction give the conditional stationary shift

$$\Delta I = -g \Delta G / \mu I^2, \quad [\Delta G] = 2, \quad [\Delta I] = 1 \quad [6.3]$$

The dimensions close: $1 + 2 - 2 = 1$. If the reference state has zero source and the quadratic potential dominates, minimizing with respect to I gives the induced potential-density shift

$$\Delta V_{\text{eff}} = -g^2 (\Delta G)^2 / (2 \mu I^2), \quad [\Delta V_{\text{eff}}] = 4 \quad [6.4]$$

The energy-density dimension closes: $2 + 4 - 2 = 4$. Equations 6.3–6.4 are conditional mean-field relations for the specified toy potential and reference-state convention. They are not a general identity for arbitrary quantum states. If the reference correlator is nonzero, the difference of squared sources is not simply the square of the difference; if I varies in space or time, gradient terms and the full field equation must be retained.

6.3 Renormalization and physical meaning

A coincident quantum correlator is ultraviolet-sensitive and requires a renormalization prescription. The state difference can cancel state-independent counterterms only when the states, background geometry, operator definition, and subtraction scheme are matched carefully. One must specify the state, the operator χ^2 , the renormalization scale, allowed local counterterms, and whether the result is local and covariant.

A scalar response to a correlation function is not established merely because one can write a source term. The source must be derived from an effective action or independently motivated microphysics; its stress-energy must be included; the coupled equations must conserve total energy-momentum; and the prediction must not be removable by a parameter redefinition or a counterterm with no independent constraint.

7. Dark energy from I-field dynamics

A canonical scalar can imitate a dark-energy component if its potential energy dominates its kinetic energy over a sufficiently long cosmological interval. For a homogeneous field on a spatially flat Friedmann–Lemaître–Robertson–Walker background,

$$\rho_I = \frac{1}{2} \dot{I}^2 + V(I), \quad p_I = \frac{1}{2} \dot{I}^2 - V(I), \quad w_I = p_I / \rho_I \quad [7.1]$$

When $\dot{I}^2 \ll V(I)$, the equation-of-state parameter approaches -1 . That is a generic property of a slowly evolving canonical scalar; it does not explain why the potential has the required scale, shape, or initial conditions. A potential chosen solely to match the observed expansion history is a fit, not a microscopic derivation.

$$\ddot{I} + 3H \dot{I} + dV/dI = J_I \quad [7.2]$$

J_I denotes a source only if it is derived from the specified interaction and quantum state. It cannot be assigned an arbitrary value at each epoch. If J_I transfers energy between the scalar and another sector, the corresponding continuity equation for that sector must contain the compensating transfer.

$$3M_p^2 H^2 = \rho_r + \rho_b + \rho_X + \rho_I + \rho_\Lambda + \rho_{\text{other}}, \quad \rho_I = \frac{1}{2} \dot{I}^2 + V(I) \quad [7.3]$$

Equation 7.3 is the homogeneous Friedmann constraint with the listed components; $\rho_\Lambda = M_p^2 \Lambda$, and ρ_{other} must not duplicate energy already included in ρ_X , ρ_I , or ρ_Λ . The acceleration equation and each continuity equation must follow from the same action. The proposed I-field branch must be tested against expansion-history measurements, growth of structure, early-dark-energy limits, and constraints on coupling to ordinary matter.

7.1 A restrained dark-energy hypothesis

The minimal surviving conjecture is that the I field has a potential with a sufficiently flat or otherwise dynamically protected region, possibly modified by a calculable state-dependent source. The mechanism for such a region remains open. No specific functional form is selected here as a derived consequence of A_0 , and no numerical value of the cosmological constant or dark-energy density is claimed to have been predicted.

The current observational interpretation of possible evolution in dark energy remains unsettled. The DESI DR2 Lyman-alpha full-shape analysis released on 30 July 2026 tightened the relevant geometric constraints and shifted that measurement toward the standard Λ CDM prediction; it does not by itself prove that Λ CDM is the final answer or eliminate every evolving model. The manuscript therefore treats $w(z)$ as an observable to fit, not as evidence already favoring the I field.

8. Can one mechanism explain both dark components?

A single parent gravitational/computational substrate is conceptually attractive, but conceptual economy is not evidence of physical unification. At the phenomenological level, a cold stable population X can have $w_X \approx 0$ while a slowly evolving I field can have w_I near -1 . Those equations describe different effective behaviors. They do not yet show that one microscopic degree of freedom produces both.

A genuine unification would require a shared action and a derived map between its microscopic states and the two cosmological regimes. It would also need to explain why the matter-like branch clusters, why the acceleration-like branch remains smooth, why the components have their observed abundances, and why their interactions do not spoil structure formation or local tests of gravity.

$$S_{\text{common}}[g, X, I, \chi, \dots] \rightarrow \{\rho_X, p_X, \rho_I, p_I\} \text{ with no double counting } [8.1]$$

Equation 8.1 is a target specification, not a completed derivation. The source sectors and their stress tensors must be defined by variation of one action. An effective energy component must not be counted once as a graviton population and again as a vacuum or scalar contribution.

9. Cosmological evolution and consistency bookkeeping

For an expanding homogeneous universe with scale factor $a(t)$, $H = \dot{a}/a$. If X and I exchange energy at rate Q , a consistent sign convention can be written as

$$\dot{\rho}_X + 3H(\rho_X + p_X) = -Q, \quad \dot{\rho}_I + 3H(\rho_I + p_I) = +Q \quad [9.1]$$

Radiation and baryons have their own standard continuity equations unless an explicit coupling is introduced. Summing all component equations must reproduce total covariant conservation. The field equation for I , the Boltzmann equation for X , and the Friedmann equations cannot be chosen independently and then combined if they imply inconsistent Q terms.

The data-analysis pipeline should fit a single parameter set jointly to the expansion history, cosmic microwave background, baryon acoustic oscillations, supernova distances, lensing, galaxy clustering, and gravitational-wave propagation. Any claimed gain against Λ CDM should survive model-comparison penalties and posterior predictive checks, not merely improve one selected data combination.

10. Observable outputs the model must produce

Observable	Required prediction	Failure signal
Background expansion	$H(z)$, distances, and a derived or constrained $w_I(z)$.	Expansion history incompatible with joint data, or arbitrary redshift-by-redshift retuning required.

Observable	Required prediction	Failure signal
Matter abundance	m_X , production rate, initial state, and $\Omega_X h^2$ from the same action.	Abundance only matches after a free normalization unrelated to the proposed dynamics.
Structure growth	Transfer function, growth rate, halo-scale behavior, and anisotropic stress.	Incorrect suppression or enhancement of power, wrong lensing response, or unacceptable gravitational slip.
Stability	Positive-norm propagating modes, controlled interactions, and a stated EFT cutoff.	Ghost, tachyon, strong-coupling pathology, or loss of predictivity inside the claimed regime.
Equivalence principle / fifth forces	Matter couplings and their range and strength.	Conflict with laboratory, Solar-System, binary-pulsar, or astrophysical limits.
Gravitational waves	Speed, dispersion, damping, polarization, and any state-dependent deviation.	Predicted deviation excluded by current waveform and propagation tests.
Correlation response	Renormalized ΔG , induced I response, and a covariant observable.	Effect disappears under consistent renormalization, violates causality, or is indistinguishable from an unconstrained ordinary scalar.

11. Parameter economy and model discipline

The phrase “no new knobs” is a research discipline, not permission to hide assumptions. Each free parameter must be listed with its physical role and the data that constrain it. If a parameter cannot be derived, it remains explicitly phenomenological.

Parameter or object	Meaning	Current status
m_X	Mass of the candidate gravitational state.	Undetermined; must follow from a consistent 4D theory or be constrained as a phenomenological parameter.
Γ_X or τ_X	Decay rate or lifetime.	Must be computed from interaction vertices; stability is not assumed without a mechanism.
Initial occupation / production rate	Sets relic abundance.	Not derived; requires early-universe initial conditions and rates.
$V(I)$	Potential of the epistemic scalar.	Unspecified function; its scale and shape are not derived from A0.
g	Cubic coupling in the illustrative $I\chi^2$ toy model.	Mass dimension +1 in 4D; physical value and origin unknown.
μ_I	I -field mass parameter in the quadratic toy limit.	Mass dimension +1; value and dynamical interpretation unknown.
Renormalized state correlator	State-dependent source candidate.	Requires a specified state, operator definition, subtraction scheme, and covariant derivation.

12. Failure modes: how the hypothesis can lose

- No consistent massive gravitational sector: the proposed state cannot be embedded in a unitary, stable 4D theory with a controlled regime of validity.
- No viable lifetime: all candidate X states decay too rapidly or inject unacceptable radiation into the early or late universe.
- Wrong abundance: no physically motivated production history yields the observed matter density without arbitrary retuning.
- Wrong clustering: the candidate behaves too warmly, develops excessive anisotropic stress, or distorts the matter power spectrum beyond observational limits.
- Unacceptable matter coupling: the I field or X sector produces an excluded fifth force or violates equivalence-principle tests.
- No derived I potential: the acceleration-like behavior requires a hand-selected potential whose scale and flatness have no independent explanation. This does not falsify A0; it falsifies or downgrades this realization.
- Renormalization failure: the correlation source is scheme-dependent, nonlocal in an uncontrolled way, or absorbed into unconstrained counterterms.
- Energy-conservation failure: the coupled stress-energy equations do not sum to a conserved total source.
- No distinctive observable: every predicted effect is degenerate with Λ CDM plus an ordinary scalar and no parameter relation separates the proposal from existing models.

A null result is scientifically useful. Excluding this realization would not by itself refute A0, because A0 and any chosen action, field content, or coupling are logically distinct commitments.

13. Numerical program

1. Specify the full 4D action, including the nonlinear gravitational-state sector, I-field potential, interaction terms, and symmetry assumptions.
2. Perform a Hamiltonian and constraint analysis of the spin-2 sector; identify its true propagating degrees of freedom and cutoff.
3. Choose one definite early-universe history and compute the X production rate, distribution function, lifetime, and relic density.
4. Compute linear cosmological perturbations and the transfer functions, then evolve nonlinear structure only within the demonstrated regime of validity.
5. Specify the quantum state of χ , define the renormalized operator G_{ren} , and calculate its response using a covariant method.
6. Solve the coupled field and Friedmann equations with consistent energy exchange and no double counting.
7. Fit the combined data set with reported priors, likelihoods, parameter degeneracies, model-selection criteria, and posterior predictive checks.
8. Publish both the positive signatures and the null predictions; state parameter regions that rule out the model.

14. Final synthesis

The dark sector remains a hard physical problem, not a naming exercise. The revised hypothesis retains two possible ingredients of the TOE: a proposed computational structure associated with gravitational states and a candidate epistemic scalar field. Their roles are now formulated directly in 3+1 spacetime.

What survives is a disciplined research direction. Massive gravitational states could behave like dark matter only if a consistent 4D theory supplies their mass, production, lifetime, and clustering. The I field could behave like dark energy only if its action supplies a stable potential and its cosmological evolution matches the data. A correlation-sensitive source may connect the field to quantum-state structure, but the source is conjectural until derived and renormalized.

The 24 traceless operators remain an abstract algebraic feature of a proposed five-level state space. They are not evidence for additional fields and do not, by themselves, explain the dark sector. A successful unification must make more predictions with fewer unconstrained parameters, not use one label to conceal multiple independent assumptions.

The decisive next step is quantitative closure: an action, a consistent spectrum, a derived relic abundance, a renormalized I-field source, and observable predictions that differ from established alternatives. If the framework cannot produce those results, the failure belongs to this realization. A0 remains the premise; the model remains answerable to reality.

Appendix A. Mass-dimension audit in 4D

Use $\hbar = c = 1$ and mass dimensions. The action S is dimensionless; d^4x has dimension -4 ; therefore $\mathcal{L}$ has dimension $+4$. The entries below assume canonically normalized scalar fields and the toy interaction written in Section 6.

Quantity	Definition / role	Mass dimension	Check
x^μ	Spacetime coordinate	-1	d^4x has dimension -4 .
∂_μ	Derivative	$+1$	Raises field-product dimension by one.
I, χ	Canonical real scalar fields	$+1$	$(4-2)/2 = 1$.
μ_I	Scalar mass parameter	$+1$	μ_I^2 has dimension $+2$.
g	Coefficient of $I\chi^2$	$+1$	$4 - [I] - 2[\chi] = 4 - 1 - 2 = 1$.
$G_{\text{ren}}, \Delta G$	Renormalized coincident scalar correlator / matched state difference	$+2$	$[\chi^2] = 2$ after operator renormalization.
ΔI	Mean-field response $-g\Delta G/\mu_I^2$	$+1$	$1 + 2 - 2 = 1$.
ΔV_{eff}	Induced potential-density shift $-g^2(\Delta G)^2/(2\mu_I^2)$	$+4$	$2 + 4 - 2 = 4$.
M_p	Reduced Planck mass	$+1$	$M_p^2 R$ has dimension $2 + 2 = 4$.
R	Ricci scalar	$+2$	Curvature contains two derivatives of the metric.

Dimensional consistency is necessary but not sufficient. It does not prove that the interaction exists, that the vacuum shift equals observed dark energy, or that the source is derived from a valid quantum state.

Appendix B. Minimum equation set for a viable cosmological solution

$$H^2 = (\rho_r + \rho_b + \rho_X + \rho_I + \rho_\Lambda)/(3M_p^2) - k/a^2 \quad [B.1]$$

$$\dot{\rho}_X + 3H(\rho_X + p_X) = -Q; \quad \dot{\rho}_I + 3H(\rho_I + p_I) = +Q \quad [B.2]$$

$$\rho_I = \frac{1}{2}\dot{I}^2 + V(I); \quad p_I = \frac{1}{2}\dot{I}^2 - V(I) \quad [B.3]$$

$$\ddot{I} + 3H\dot{I} + V'(I) = J_I \quad [B.4]$$

The first equation uses the convention in which k is the normalized spatial-curvature parameter and ρ_Λ denotes only a separately specified cosmological-constant contribution. If $V(I)$ is already being used as the dark-energy source, it must not also be absorbed into ρ_Λ . A model with energy transfer Q must derive the matching source J_I and the corresponding X -sector collision term from the same interaction.

These equations are a minimum bookkeeping set, not a closed predictive system until the equations of state, potential, production term, initial conditions, and perturbation dynamics are specified.

Appendix C. Decision ledger

Statement	Status
Four-dimensional canonical scalar fields have mass dimension one.	Established dimensional result.
The stated cubic coupling $g\chi^2$ has $[g] = +1$ in 4D.	Derived from the stated interaction and canonical normalizations.
A stable, nonrelativistic population redshifts approximately as a^{-3} .	Standard continuity-equation result in the pressureless, uncoupled limit.
A slowly rolling canonical scalar can have w close to -1 .	Standard scalar-field cosmology result; does not derive the potential.
The graviton is a fundamental five-level computational register.	TOE conjecture; not established experimentally.
The 24 traceless operators source dark matter or dark energy.	Open conjecture; no derived dynamics or distinctive prediction yet.
The I field is sourced by a renormalized quantum correlation.	Toy ansatz; requires covariant derivation, renormalization, stability, and a measurable consequence.
One microscopic substrate explains both dark components.	Unproven unification hypothesis.

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Research-status note

This is a speculative research artifact. Standard cosmological equations and the field-theory dimensional analysis are used as constraints. The gravitational qdit, I-field ontology, correlation-source mechanism, and unified dark-sector interpretation remain conjectures until their dynamics are fully specified, their predictions calculated, and their agreement with observation independently tested.